REMARKS/ARGUMENTS

Claims 1-7, 12, 13, 16, 17, 19, and 25 have been resubmitted. Claims 1, 2, 4, 6, 7, 12, 13, 16, 17, 19, and 25 have been amended. Claims 8-11, 14, 15, 18, and 20-24 have been canceled. New Claims 26-50 have been added.

The Examiner objected to Claim 23. The Examiner rejected Claims 17-19 and 21-24 under 35 U.S.C. Section 112, second paragraph as being indefinite. The Examiner also rejected Claims 1-2, 4-5, 7-8, 10, 12, 14, 17, and 20-24 under 35 U.S.C. Section 102(b) as being anticipated by Petzoldt *et al.* The Examiner also rejected Claims 1-5, 7-10, 12, and 20-25 under 35 U.S.C. Section 103(a) as being unpatentable over International Application WO 98/54531. The Examiner also rejected Claims 3, 9, 16, and 19 under 35 U.S.C. Section 103(a) as being unpatentable over Petzoldt *et al.* The Examiner also rejected Claims 6, 11, and 13 under 35 U.S.C. Section 103(a) as being unpatentable over Petzoldt *et al.* and WO 98/54531 in view of Marder, Arnold (Arnold R. Marder "*Effects of Surface Treatments on Material Performance: Deposition Surface Treatments*," ASM Handbook, Vol. 20, 1997, pp. 1-18).

Examiner Interview

[Reserved]

Amendments to the specification

Paragraph [035] has been amended to add the sentence: "The aluminum conversion layer may be deposited on the titanium-based substrate at a temperature of less than about 450° C." Support for this amendment may be found in the original claims (e.g., Claim 6).

Support for amendments to the claims

Support for the amendment of claim 2 can be found, for example, at page 6, paragraph [023] of the specification.

Support for the amendment of claim 7 can be found, for example, at page 10, lines 10-13 and Figure 6 of the specification.

Claim Objections

The Examiner objected to Claim 23 because the claim did not end with a period. Claim 23 has been canceled.

Claim rejections – 35 U.S.C. section 112

The Examiner rejected Claims 17-19 and 21-24 under 35 U.S.C. Section 112, second paragraph as being indefinite. In Claim 17 the antecedent basis of the phrase "a protective coating was unclear".

Claim 17 has been amended to delete the phrase "a protective coating". Claim 19 as amended depends directly from Claim 17.

Claims 18, and 21-24 have been canceled.

Petzoldt *et al.*

Petzoldt *et al.* (U.S. 5,300,159) teaches a method for manufacturing tools from titanium, in which aluminum is deposited on a titanium tooling insert by ion vapor deposition, and the coated tooling insert is heated to 1200 to 1700° F (649 to 927° C) for 30 minutes to 3 hours to form a titanium aluminide. The ion vapor deposition of Petzoldt *et al.* involves application of a highly negative electrostatic potential to the substrate, and electrostatic deposition of aluminum on the substrate. The highly negativ electrostatic potential applied to the

substrate establishes a glowing ionic discharge of inert gas around the substrate which cleans the substrate surface (column 2, lines 44-47).

In contrast, the instant invention claims a method for coating a titanium-based substrate or surface, in which aluminum deposited on a substrate surface reacts in two ways: 1. oxidation of a portion of the deposited aluminum to form an alumina surface layer, and 2. reaction of a further portion of the deposited aluminum with Ti in the substrate to form a titanium aluminide, especially the phase $TiAl_3$.

Both of reactions 1. and 2. are dependent on an appropriate, controlled temperature regime – if the temperature is too high, the deposited Al will quickly diffuse into the substrate and react with Ti before a desired alumina layer can be formed (see, for example, page 11, lines 17-23 of the specification). Further, if the temperature is too high the titanium aluminide phase tends to be Ti_3Al, which is undesirable as compared with $TiAl_3$ (see, for example, page 11, lines 14-17 of the specification). Moreover, reactions 1. and 2. may occur at distinctly different temperatures, for example, oxidation of aluminum (reaction 1.) may be promoted at a relatively low temperature of about 400° C, while formation of $TiAl_3$ may be promoted at a higher temperature of about 700° C (see, e.g., Example 1 at page 10, lines 10-13 of the specification). Applicant has also disclosed that a controlled temperature regime in which the temperature is increased, and subsequently decreased, at a defined rate per unit time (see, for example, page 7, lines 4-7 of the specification) may be used to provide both a layer of alumina and a titanium aluminide layer comprising $TiAl_3$, which layers together form an oxidative protective coating for Ti-based substrates. Applicant has also found that careful control of the temperature at which Al diffuses into the substrate can provide increased strength and fatigue life of coated components (see, for example, page 8, lines 24-27 of the specification).

In contrast to the instant invention, Petzoldt *et al.* does not disclose heating at a controlled or defined rate, nor promotion of reactions 1. and 2. by the use of two different temperatures, nor the formation of an alumina surface layer. In fact, Petzoldt *et al.* teaches away from Applicant's invention by disclosing heating the substrate and deposited Al layer to a temperature of 1200 to 1700° F. Such temperatures do not promote, nor allow, formation of a surface alumina layer, and do not promote formation of a $TiAl_3$ titanium aluminide phase. Furthermore, the uncontrolled cooling from such temperatures of Petzoldt *et al.* may promote cracking of the titanium aluminide coating on the T-based substrate. In this regard, Applicant notes that cracking of a titanium aluminide layer will destroy the effectiveness of an oxidation protective coating on titanium.

Still further, in the instant invention, the temperature at which Al is deposited on the titanium-based substrate is defined. Deposition of Al on the titanium-based substrate at an inappropriate temperature is associated with a number of drawbacks (see, for example, paragraphs [029] and [030] of the specification). In contrast to the instant application, Petzoldt *et al.* does not disclose an appropriate temperature at which aluminum is deposited on the titanium-based substrate.

The instant application claims a method involving cleaning of a titanium-based surface, using a cleaning solution, such as a solution of KOH, prior to deposition of Al.

In contrast to the instant invention, Petzoldt *et al.* does not disclose use of a cleaning solution to clean a titanium-based surface. Instead Petzoldt *et al.* teaches way from the invention by describing cleaning the substrate surface with a glowing ionic discharge of inert gas.

Applicant submits that Petzoldt *et al.* does not anticipate, nor render obvious, the amended and new claims presented herein.

Raybould *et al.*, (WO 98/54531)

Raybould *et al.* (WO 98/54531) teaches a titanium-based metal heat exchanger and a method of manufacture, in which aluminum is deposited on a titanium substrate, and the coated substrate is heated under vacuum to about 1200° F (649° C), whereby titanium aluminide and a surface layer of aluminum oxide (i.e., alumina) are formed.

In contrast to the instant invention, WO 98/54531 does not disclose the use of two different temperatures for the promotion of reactions 1. and 2. as described hereinabove, i.e., 1. oxidation of a portion of the deposited aluminum to form an alumina surface layer; and 2. reaction of a further portion of the deposited aluminum with Ti in the substrate to form a titanium aluminide, especially the phase $TiAl_3$. In particular, formation of an alumina layer (reaction 1.) is favored by a relatively low temperature (for example, about 400° C), while diffusion of Al into the Ti-based substrate and formation of $TiAl_3$ (reaction 2.) is favored at a higher temperature (for example, about 700° C). (See, e.g., Example 1 at page 10, lines 10-13 of the specification.) As noted hereinabove, the outcome of reactions 1. and 2., which lead to the formation of the oxidation protective coating of the instant invention, is highly temperature dependent.

Applicant discloses a temperature regime, for formation of an oxidation protective coating, in which the temperature is increased at a rate of about 25 to 100° C per hour, and in which cooling is controlled at a rate of about 15 to 60° C per hour.

In contrast to the instant invention, WO 98/54531 discloses a temperature regime in which heating from 1000 to 1200° F is at the rate of about 200° F per hour, and in which cooling from 1200 to 1000° F is also at the rate of about 200° F per hour.

As noted hereinabove, in the instant invention the temperature at which Al is deposited on the titanium-based substrate is defined. Deposition of Al on the titanium-based substrate at an inappropriate t mperature is

associated with a number of drawbacks (see, for example, paragraphs [029] and [030] of the specification). In contrast to the instant application, WO 98/54531 does not disclose the temperature at which Al is deposited on the titanium-based substrate.

Applicant submits that WO 98/54531 does not anticipate nor render obvious the amended and new claims presented herein.

Petzoldt *et al.* and WO 98/54531 in view of Marder, Arnold R.

The Examiner asserted that Marder, Arnold (ASM Handbook, Vol. 20, 1997, pp. 1-18) teaches the temperature of deposition for PVD processes.

Marder, Arnold describes effects of surface treatment on material performance, wherein Table 15 (page 13) compares various PVD process characteristics. Applicant notes that most of these processes are line of sight techniques, or are presented in the context of simply depositing a coating, and therefore are not relevant to the instant invention which involves non-line of sight deposition of a material (Al) which then undergoes two separate, highly temperature dependent reactions after deposition.

Applicant submits that Petzoldt *et al.*, alone or in combination with WO 98/54531 and Marder, Arnold, does not render obvious the amended and new claims as presented herein.

Allowable subject matter

The Examiner stated that claims 15 and 18 would be allowable if rewritten to include all of the limitations of their respective base claim and any intervening claims.

Claims 12 and 17 have been amended to include all of the limitations of claims 15 and 18, respectively, and any intervening claims.

CONCLUSION

Applicant submits that the claims are now in condition for allowance. Reconsideration and withdrawal of the Office Action with respect to Claims 1-25 is requested.

In the event the examiner wishes to discuss any aspect of this response, please contact the attorney at the telephone number identified below.

Respectfully submitted,

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